HUMAN LARYNX IN RELATION TO PHONATION

Hints on Voice Culture

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Voice is sound produced by the mouth, especially human utterance in speaking, shouting, singing etc. Culture is improvement by mental and/or physical training, intellectual development. Hence voice culture is improvement by mental or physical training of the sound uttered by the mouth in speaking, shouting, singing etc.

The voice, as we hear it, is the sound produced by the larynx and modified by the resonators above and below it and in it. So, to improve the voice by training, it is necessary to know the anatomy of the organs concerned with the mechanism of production of the voice and increase of its pitch.

The human larynx consits of a number of cartilages connected by ligaments, membranes and muscles. (Fig. 1 and 2). It is lined by a mucous membrane. The thyroid cartilage is easily seen in the neck. It has two plates fused in front but diverging behind. The cricoid cartilage is signet-ring shaped with a plate behind and an arch in front and is situated on top of the highest ring of the trachea. The thyroid cartilage articulates with the cricoid cartilage by two small processes which project from the lower and back parts of the plates. The two arytenoid cartilages sit on the cricoid plate and at the base of each of these there are two processes, one projecting into the cavity of the larynx, called the vocal process, and the other projecting outwards, called the muscular process. To the vocal process is attached the vocal fold. The apex of the pyramid-shaped arytenoid cartilage projects upwards. The upper margin of the arch of the cricoid cartilage on each side gives attachment to a membrane which ends in a free thickened border above. This is under cover of the lower half of the plate of the thyroid cartilage on each side. This is the crico-vocal membrane or *cous elasticus* and the thickened border, the vocal ligament. The free upper border is attached to the back of the thyroid plate of its corresponding side, just outside the midline and about midway between the upper and lower borders.

The epiglottis is leaf-shaped and is attached by its stalk to the back of both the plates of the thyroid cartilage just below the laryngeal prominence. Its outer borders are attached to the arytenoid cartilages by the aryepiglottic folds. The inlet of the larynx is thus shifted from the level of the glottis (to be defined later) to a higher one and the boundaries of the inlet are, the free margin of the epiglottis, the free margins of the atyepiglottic folds and the tops or apices of the arytenoid cartilages. This inlet leads from the pharynx to the larynx and this in turn leads into the trachea. The mouth cavity between the hard and soft plates on the one hand and the tongue on the other, leads behind into the pharynx.

The interior of the larynx is lined by mucous membrane. Commencing from the level of the inlet of the larynx on either side, it descends and forms a fold by turning outwards and upwards. Traced upwards, the mucous membrane from the inner aspect of the cricoid cartilage lines the crico-vocal membrane and turns outwards, covering its upper border and becomes continuous with the outwardly directed layer of the upper fold. The upper fold is the false vocal fold and the lower the vocal fold. Between them the mucous membrane forms a pouch called the ventricle of the larynx.

At the cut edges of a section dividing the larynx into a front and a rear half, the vocal fold with its contents appears wedge-shaped, base outwards and edge inwards. The fold is attached in front to the back of the thyroid plate and corresponds to the front attachment of the vocal ligament. Behind, it is attached to the vocal process of the arytenoid cartilage. The false vocal fold, similarly, is attached to the thyroid cartilage, just above and outer to the attachment of the vocal fold and behind it is attached to the front of the main body of the arytenoid cartilage. The vocal folds and the interval between them are together known as the "glottis'. The gap between the vocal folds and between the medial parts of the two arytenoid cartilages is known as the *rima glottidis*. This is therefore divisible into two parts, a long front part bounded on each side by the vocal folds and short cartilaginous part between the two arytenoid cartilages.

There are several muscles controlling the width of the glottic aperture and these are:

1. The thyro-arytenoid muscle extending from the back of the thyroid plate to the front of the arytenoid cartilage. The inner part of this muscle is tucked in the vocal fold and is known as the 'vocalis' muscle. (Fig. 3).
2. The cricoarytenoid lateralis extending backwards from the arch of the cricoid cartilage to the muscular process of the arytenoid cartilage. (Fig. 3).
3. The cricoarytenoid posterior, extending from the back of the cricoid plate to the muscular process of the arytenoid cartilage. (Fig. 4)
4. The cricothyroid extending from the arch of the cricoid cartilage to the lower margins of the thyroid cartilage and to the front border of the lower process of that cartilage.
5. The interarytenoid muscle connecting the arytenoid cartilages at their back surfaces. (Fig. 4).

The thyroartytenoid muscle, the cricoarytenoid lateralis and the interarytenoid muscles form a sphincteric girdle at the glottic level.

The vocalis: This muscle extends from the vocal process of the arytenoid cartilage to the back of the thyroid lamina just outside the median plane. Some authorities believe that, the fibres run parallel end to end; but others believe that on their way some fibres turn inwards to get attached to the vocal ligament; in other words, the vocal ligament receives insertion of the vocalis fibres along its length at regular intervals. (Strong 1935) (Fig. 5). This is however denied by Sonesson (1960) who believes that fibres are parallel. But he believes that the fibres in their course are attached to the upper and lower walls of the vocal fold. The present author has also observed such fibres. These fibres have the effect of thinning the vocal fold by approximating the two walls and creating a shape of the fold similar to to that of a hollow-ground razor. (Fig. 6).

There are numerous glands in the aryepiglottic folds, false vocal folds base of the epiglottis and in the saccule. The saccule is a secondary outpouching from the ventricle of the larynx in its front part. This is very rich in glands and its mouth overlooks the front end of the vocal folds and in under cover the front part of the false vocal folds. This saccule plays a very important part in the lubrication of the vocal cords.

The vocal fold is so shaped that, in cross section, it presents neither too broad an inner surface nor too thin an edge. Animals with too broad an inner surface, as for example the ruminants, can no doubt produce tones of a mellow quality, but the range is very limited since very high pitches cannot be produced. In some of the primates possessing a very thin-edged vocal fold, the sound produced by them is so shrill that it is very unpleasant to hear. The human vocal fold is intermediate between the two and long enough to permit a wide range of pitch.

Mechanism of phonation:

The larynx has been compared to many mechanical devices capable of producing sound. Galen, in the early Christian era, compared it to a flute; Fabricius, to the pipes of a mouth organ; Dodart, to a clattering

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Figure 1. *The cartilages and ligaments of the larynx — viewed from behind.*

1. *Aryepiglottic fold.* 6. *Back surface of the cricoid plate.* 7. *Lower process of thyroid plate.*
8. *Arytenoid cartilage.* 11. *Hyoid bone.* 12. *Epiglottis.*

Figure 2. *The interior of the larynx.*

1. *Epiglottis.* 2. *Aryepiglottic fold.* 5. *Vestibular fold.* 6. *Mucous membrane covering the inner surface of cricoid cartilage.* 7. *Cricoid lamina.* 11. *Thyroid cartilage.* 12. *Vocal fold.*

Figure 3. *Muscles of the left half of the larynx viewed from the left side.* (*the left thyroid lamina has been removed*).

T. *Cut thyroid plate.* A. *Arytenoid cartilage.* C. *Cricoid cartilage.*
3. *Thyroarytenoid muscle.* 4. *Cricoarytenoid lateralis.*

Figure 4. *Muscles of the larynx viewed from behind.*

1. *Cricoarytenoid posterior.* ; 2. *Interarytenoid — horizontal and oblique parts. Only one limb of the X-shaped oblique part of the muscle is shown.*

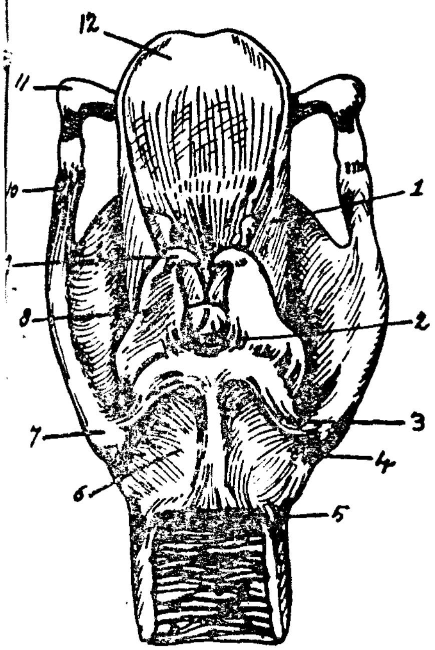


Fig. 1

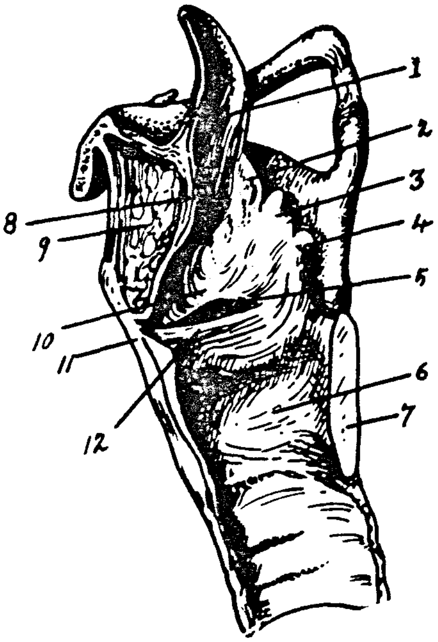


Fig. 2.

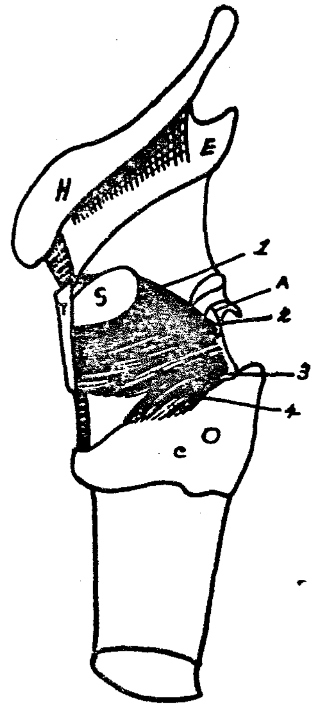
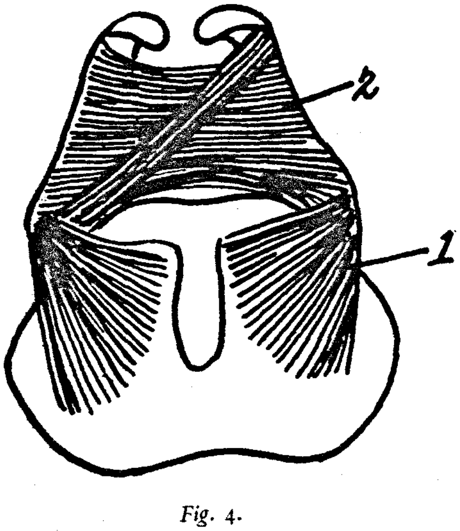


Fig. 3.



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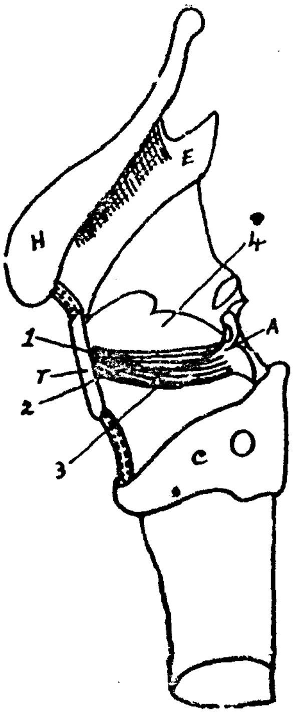

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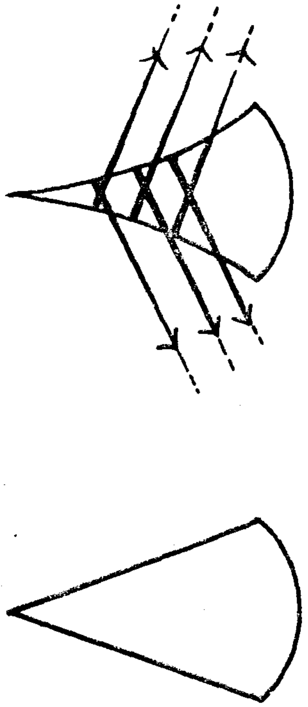

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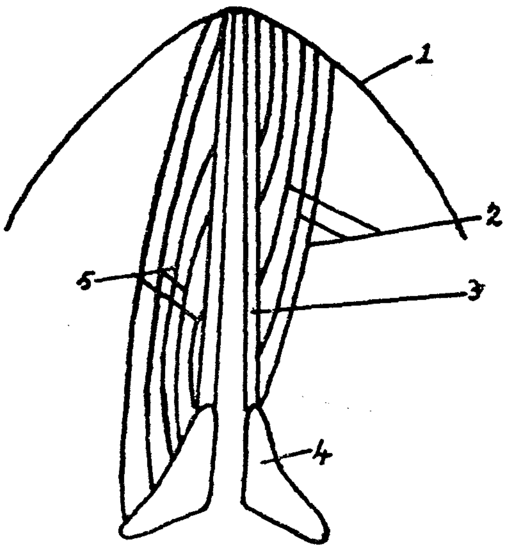

Fig. 7.

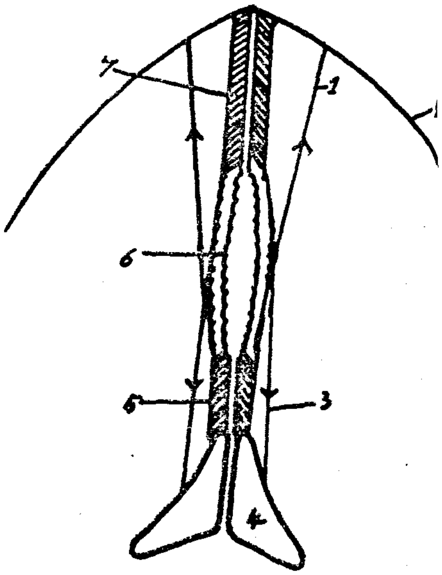

Fig. 8.

window frame; Ferrein, to a spinet; Megendie, to a reed instrument and Savaart, to bird-catcher's decoy. (Moure and Boyer, Cited by Negus, 1929). Aikin (1900) compared it to a church organ, Illingworth (1895) to a trumpet and Jackson and Jackson (1947) to the lips of a bugler. Pressman (1938), in explaining the pitch changes compared it to the strings of a violin. Thus, it is seen, tht, the larynx has been described by each worker according to his own interpretation.

The mechanism of phonation may be considered under the following heads:

1. The mechanism of phonation for low range.
2. The mechanism of variation of pitch.

1. *The mechanism for low range:* This involves, first, the adjustment of the vocal folds for phonation. The arytenoid cartilages are first bodily approximated by the interarytenoid muscle. The transverse part of the muscle brings to two basal parts of the cartilages together. The oblique parts tilt the apices of the cartilages and bring their front margins together. The vocal processes are rotated towards the median plane by the cricoarytenoid lateralis. The cricothyroid and the sternothyroid muscles draw the thyroid cartilages downwards and forwards and fix front ends of the vocal folds. The cricoarytenoid posterior fixes the posterior ends of the vocal folds by bracing back the arytenoid cartilages. The cricopharyngeus holds the cricoid cartilage firmly fixed against the vertebral column. Now the vocal folds are set for vibration and they need only be tensed to set themselves and the air into vibration. The thyroarytenoid muscles now contract and tense the margins of the glottis which has been narrowed by the movement of the vocal folds to the median plane. Air, as it passes through the larynx, is thus impeded by the narrow glottic chink and hence the pressure of air in the trachea rises. Once this pressure reaches a sufficient height, the air is able to force open the margins of the glottis. As soon as this puff of air escapes, the pressure of the air in the trachea falls and now the glottic margins recoil and this cycle, repeated a number of times, constitutes the vibrations of the vocal folds.

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Figure 5. *Muscles of the larynx after removal of the bulk of the thyroarytenoid muscle.*

1. *Thyrovocalis.* 2. *Vocal ligament.* 3. *Aryvocalis.* 4 *Ventricle.*

Figure 6. *Diagram to show the action of the thyroarytenoid muscle in sharpening the vocal folds. The arrows indicate the direction of pull.*

Figure 7. *The thyrovocalis of the right side and the aryvocalis of the left side and their attachment. (diagrammatic representation).*

1. *Thyroid lamina.* 2. *Thyrovocalis.* 3. *Vocal ligament.* 4. *Arytenoid cartilage.* 5. *Aryvocalis.*

Figure 8. *Diagrammatic representatation of the action on the vocal folds of two sets of fibres, one, aryvocalis, and the other, thyrovocalis, crossing each other.*

1. *Thyrovocalis.* 2. *Thyroid cartilage.* 3. *Aryvocalis.* 4. *Arytenoid cartilage.* 5. *and* 6. *Lax segment of the vocal folds.* 7. *Tensed segments of the vocal folds. Arrows indicate the direction of pull.*

Mode of vibration of the vocal folds: The lower surfaces of the folds, when apposed, present a dome shape and each side of the dome is set an angle of about 45 degrees to the axis of the lumen of the larynx. Air strikes this surface at right angles and hence the folds are pushed upwards and outwards. Hence there is a combined vertical and horizontal movement of the folds. Negus (1929) states that the vocal folds move in the horizontal plane during the vibrations with a slight eversion of the edges. Pressman and Kelemen (1955) state that the movement of the folds is in a wave form from underneath upwards and they compare the movements to those of a pair of delicate hands alternately showing the palms and the dorsa.

Whereas this is the generally accepted view regarding the initiation of phonation and vibration of the vocal folds, Husson (1950 and 1953, cited by Pressman and Kelemen, 1955) describes the vibration of the folds on the basis of neuro-physiology. He believes that the vocal folds respond beat to beat with the action potentials of the same rhythm taking place in the recurrent laryngeal nerve which supplies the muscles of the larynx. This action, according to Bremer (1947, cited by Pressman and Kelemen, 1955) originates in the brain cells. According to Husson, the laryngeal muscle-fibres have a refractory phase of 2 m. secs., the same as the fibres of the recurrent laryngeal nerve and the two, the muscle and the nerve, are in phase.

Curry (1940) believes that the maximum limit of the action potentials is reached at frequencies above a thousand and hence the thyroarytenoid cannot act under nervous control.

It is interesting in this connection that Pressman and Kelemen (1955) give importance to the aryvocalis muscle fibres which are set like the teeth of a comb and state that their action potential results in an alternate pulling and approximation of the vocal folds, the number of times such as phenomenon occurring being as many times as there are impulses in the recurrent laryngeal nerve. This view is however untenable since, among some of the lower animals, the aryvocalis is absent.

Mechanism of alteration of pitch: Alteration of pitch can be brought about in four ways and these are:

1 Alteration in the tension of the vocal folds.
2 Alteration in the configuration of the folds.
3 Alteration in the length of the vibrating segment of the fold.
4 Alteration in the diameter of the aperture between the vocal folds, particularly in high pitches.

1. *Alteration in tension:*

Mayer believed that the vocal ligament was responsible for the necessary tension in the vocal folds. But Negus (1929) put forth the view that the thyroarytenoid muscle imparts tension to the vocal folds and this view is now generally accepted. As more and more of the fibres contract, the tension rises.

The vocal folds can be compared to a vibrating string (though the comparison is, strictly speaking, not quite applicable). Under a constant length, the frequency of vibration of a string varies directly as the tension and hence, like the string, when the tension in the vocal folds increases, the period of vibration decreases. When the tension increases the amplitude vibration also diminishes and hence the frequency rises. With increasing tension, the recoil is also faster and therefore the frequency rises with increase in pitch.

2. *Alteration of configuration:*

Pitch rises according as a thicker or thinner edge of the vocal folds vibrates.

Negus believes that the aryvocalis muscle, by pulling at the conus elasticus, which constitues part of the lower wall of the vocal fold, approximates it with the upper wall and hence a shorter margin of the fold vibrates.

Husson and Tarnaud (1932, cited by Curry, 1940) and Husson (1933, 1934 cited by Curry, 1940) distinguished four modes of vibration of the vocal folds in which the glottic margins undergo considerable changes. In the very low pitches, the cords are relaxed, the chin drawn back into the neck to relax the muscles linking the larynx, the hyoid bone and the lower jaw. In the lower range, as the pitch rises, the thyroarytenoids contract and swell up and hence the area of contact of the folds increases. This goes on upto the limit of what they call the chest register with an open quality. Then a change in mode of vibration takes place. The thyroarytenoid muscles, having reached the maximum tension, cannot increase the tension any more. Now the external laryngeal muscles come into play. The hyoid bone with the laryngeal cartilages moves upward and forward towards the lower jaw. The supra and infra laryngeal muscles hold the larynx in place. The crico thyroid effects a forward pull on the thyroid cartilage. Due to the separational pull the cord now increases in tension further and a lesser area of contact result. The cords revert to the wedge-shaped form in cross section, the contraction of the thyroarytenoid having altered the shape previously.

In the third mode of vibration, which comes under the falsetto, according to Husson and Tarnaud, there is an accentuation of the activity of the external laryngeal muscles. Thus a still thinner cord results, the thyroarytenoid relaxing now, touching only 2 mm. in depth. According to them, the vertical component of the vibration considerably increases now, the horizontal component being greater in the lower ranges.

According to Husson and Tarnaud, in the whistle register, applicable only to soprano voices, the thyroarytenoid muscles do not vibrate as a mass and an aperture is left, located in front or the middle third of the glottis and is about 2 mm. in cross secton at the widest point. The cords do not vibrate as a mass and are tightly closed except at this paerture. Only the edges of the cords now vibrate.

While Negus explains the thinning of the cords in very high pitches on the basis of the acton of the aryvocalis muscle fibres, Husson and Tarnaud explain the thinning owt as due to the separational pull on the attachments of the cord.

3. *Alteration in the length of the vibrating segments of the fold*

When a string vibrates under constant tension, if a portion of the vibrating string is damped, the segment betwen the point of stimulation of the string and the place of damping vibrates at a higher frequency. Thus frequency is inversely proportional to the length of the string. But, in the case of the vocal fold, a lengthening of the fold also occurs. The lengthening of the fold is probably due to the cricothyroid muscle which effects a forward pull as well as downward pull on the thyroid cartilage.

Pressman (1938) and Pressman and Kelemen (1955) describe a definite elongation of the cords to about one-third of their lengths. In a cinematographic film of the action of the vocal folds, they find that, in low pitches, to start with, the cords are relaxed, fore-shortened and bowed out, fore-shortening due to the thyroid certilae sliding backward and the arytenoid falling forward. A gap, wider posteriorly, exists between the cords, in that range of pitch. As the pitch rises the gap closes, the cords elongate and they parallel. Mussay (1951) agrees with Pressman that there is an elongation of the cords.

While increase of tension has the effect of directly increasing pitch in the ratio of the square root of tension, the accompanying increase in length acts in an inverse manner. This is annulled in the larynx by a mechanism to make the vibrating segment shorter.

Negus (1929) does not consider that the cords vibrate in segments. According to him, as stated before, the tension of the cords is solely dependent on the thyroarytenoid muscle. However, in falsetto notes, he says the external part of the thyroarytenoid muscle relaxes and only the internal tense portion vibrates and that, over a certain length only.

Strong (1935) believes that the cord vibrates in segments due to the action of the aryvocalis. In his opinion, by a specific innervation at a given time of a group of muscle fibres controlling a particular segment, that particular segment will be put on the stretch. If tension remains constant and the length of the vibrating segment is altered, then the pitch can be controlled, a shorter segment naturally giving rise to a higher pitch.

Pressman and Kelemen (1955) and Pressman (1938) state that, as the pitch rises, the cords elongate, become tense and parallel. A further rise in pitch is brought about by a progressive damping of one cord by the other from behind forwards, thus providing for a shorter and shorter segment situated anteriorly, to vibrate.

4. *Alteration in the diameter of the aperture between the vocal folds during vibration*

Negus (1929) mentions about the presence of an elliptical aperture in the falsetto notes, the aperture being located at the middle of the glottis. The aperture is, in his opinion, due to the fact that the inner part of the thyroarytenoid is alone tense, the outer part being relaxed. The glottic margins, being thus unsupported, get blown out and this occurs at the point of least firmness of closure together of the cords.

Husson and Tarnaud (cited by Curry, 1940) state that the opening seen in the falsetto rgister is due to the optical effect of the relative periods of lcosure and opening of the cords. In the lower register, when the period of closing is greater than or equal to the period of opening and recoil, the appearance in a laryngoscope is that of a closed glottis, whereas in the falsetto the closed period is shorter than that of opening and closing and hence the glottis appears open. However, Tarnaud (cited by Curry, 1940) states that, in the whistle register of soprano voices, there is an elliptical aperture at the point of least rigidity of cords which may be in the middle or anterior third. This is explained by him as being probably due to the relaxation of the thyroarytenoid and interarytenoid muscles. He also attributes this opening to the fact that the vestibular folds (false vocal folds) move closer and press down on the vocal cords allowing only the margins of the cords to vibrate.

Glottic chink and vibration of the vocal folds

Negus (1929) states that it is not necessary that the margins of the glottis must be absolutely in opposition. Such an action he says, is impossible in deer and oxen. All that is necessary, he adds, is that the glottis should be reduced to a narrow chink, so that air might pass through and separate the margins.

Pressman and Kelemen (1955) state that as soon as the glottic margins are brought together by adduction, by a subsequent lateral pull of the glottic margins by the appropriate fibres of the thyroarytenoid, a chink is produced. The lateral pull is against the combined action of the adductor muscles and the inherent elasticity of the cords themselves. This, they compare to the backward pull of the taut bow string by the arm of an archer. The arm of the archer they compare to the thyroarytenoid fibres. The pull either involves the length of both the cords or selective equal anterior segments of the cords, depending on the pitch to be produced. When the pull has re-established the chink of the glottis to the required length and width corresponding to the desired pitch of the tone, the air from below forces its way through the chink. In so escaping the air under pressure causes a further separation of the margins and vibrations. The movement of the cord is limited to that portion of the cord that has been pulled aside preliminarily.

To sum up, all the factors responsible for increase of pitch play an important part. The ary and thyro vocal fibres have a role in each of the three latter modes of increase of pitch. They can (1) by approximation of the upper and lower wall of the glottis cause the glottis margins to become thinner, (2) by varying the lengths of the tense segments, they control the degree of pitch and (3) by the opposed action on the vocal ligaments of their fibres which cross each other, they act to produce a relatively lax segment which passively opens due to the air pressure and vibrates. (Fig. 7 and 8).

The vocal cords and the quality of the voice:

The vocal cords, apart from producing the fundamental note, also produce the partials. The thicker the cords, the more the number of partials and the closer the partials are to the fundamental, the more pleasing the voice. Thus the quality of the voice is determined at the level of the glottis itself. Man's vocal folds are neither too sharp nor too rounded and hence his voice is pleasing to hear as well as capable of wide range of pitch.

The Resonators

The lungs, the air passages below the larynx, the cavity of larynx itself above the level of the glottis, the ventricle and the cavities of the pharynx and mouth are resonators which modify the voice and amplify it. The sound produced at the glottic level is too feeble. The supraglottic resonators, viz. the pharynx and the mouth cavities are selective resonators since, the cavities can be altered in shape and size at will. The nasopharynx (that part of the pharynx above the soft palate, continuous in front with the nasal cavities) takes very little part in the resonance, unless nasal sounds are deliberately produced, as for e.g. in the French word FIN.

There are certain factors which determine whether a singer possesses a voice which is particularly fine, moderate or poor.

These factors are:

The bellows: The larger the air capacity of the lungs, the better, that the singer may avoid the necessity for too may breaths, be able to sustain a long phrase without losing control through 'shortness of breath' and to provide sufficient power on occasion for intensities of great volume.

Size of the chest alone is of no advantage unless the function is satisfactory. Big chest with poor mobility is a poor pair of bellows. The lungs must be capable of rapid filling and a steady controlled emptying to provide a flow of breath necessary for sustained and controlled song. This requires therefore the muscles of the chest wall, the diaphragm and upper abdominal wall to be capable of controlled movement.

Vibrating folds: The larynx, particularly vocal cords, must be free from damage resulting from disease or injury. It should be also of sufficient size. Mobile parts of the larynx must be capable of full range of normal movements. Apart from the coarse movements possessed by the healthy larynx the muscles regulating the stiffness of the cords, both by stretching, firming or hardening actions and also those controlling cord-shape and the way in which the cords' free margins are apposed, must be capable of extremely delicate adjustment. Glands of the larynx must provide suitable quantities of thin mucus to act as a lubricant of satisfactory consistency for the cords.

The resonators, which comprise the chest, pharynx and mouth, should be large, free from disease or injury. The muscular component of the pharynx and mouth and especially tongue and soft palate must be capable of rapid and controlled activity, without excessive contraction. Training does enable the singer to control the various muscles of the tongue, soft palate and pharynx with unusual precision and selectivity. The parts must be appropriately lubricated with adequate quantity of saliva or mucus. No muscle must be put under so much tension that it leads to a sensation of aching or tiredness in the throat or neck during the course of an evening's singing.

Singing is not a 'natural' act but an accomplishment as 'artificial' as juggling and more so than acrobatics. Potentially fine voices are, therefore, unusual accidents of nature and really great voices might fairly be described as freaks.

Hints on voice culture?

A good voice is a gift and a good singer inherits this. This is so since the shape and size of the organs are genetically determined. The parts of the nervous system concerned with rendering and appreciation of music are also inherited.

Music is essentially an imitative art and learnt from masters who are faithfully imitated by the pupils. Hence it is likely that faulty methods of rendering are imitated as well. The teacher has, therefore, a heavy responsibility in having to see that the right type of training is imparted and the correct method of voice culture encouraged.

Training the vocal apparatus means training the muscles controlling the vibrations of the vocal folds and shape and size of the resonators and amplifiers. It is necessary therefore to investigate scientifically into the shape of the resonators, the vocal cords etc. the accessory muscles controlling the position of the larynx in the case of reputed and great singers.

Musicians of repute are known to have started their musical career very early. While it is good to commence voice culture early enough, the limitations of the vocal apparatus in the still immature pupil should be borne in mind and too strenuous a training not resorted to right from the start. The length of the vocal folds and general size of the larynx alter during puberty and adolescence and the distinct quality of the male and female voices are established at the commencement of adulthood. Strenuous training should, therefore, commence only when the cords and other structures in the vocal apparatus have attained their final shape and size. The training may commence early enough, say 6 to 10 years of age, but the pupil encouraged to sing to the limits of his or her range only. This is about a maximum of 1½ octaves. The training should be primarily aimed at cultivating in the pupil a 'musical' ear and exercising the vocal muscles so as to be in a fit condition to undertake more complicated tasks later. The capacity to produce the desired pitch with ease and to interpret a note in terms of *svara*-s should particularly be stressed.

A sound body is an essential pre-requisite for a singer. Particular attention should be paid to the development of the chest by breathing excercises as for instance *pranayamama*. The abdominal muscles should be kept in good tone. *Yoga-asana*-s,, directed towards keeping up the tone of the abdominal muscles are invaluable aids.

Pupils should be trained to avoid facial contortions and unnecessary bodily movements, which apart from being unaesthetic, involve unnecessary waste of energy. They should be taught, right from the start, to keep their heads reasonably steady and conserve energy by minimising bodily movements. Facial contortions affect the quality of the sound that ultimately emanates from the mouth. The larynx should be kept low and the pharynx and the mouth wide enough for good resonance. Stretching the neck by tilting the head back while rendering high pitch notes should be avoided, since this has a tendency to lengthen the pharynx and narrow it.

Only very little rise in pitch can be effected by raising the expiratory pressure. This should not be resorted to and if a note cannot be produced ordinarily at high pitches, they should not be done so by forced expiration. In other words, a high pitched note should not be forced. If it cannot be produced by normal expiratory effort in singing, it should not be attempted at all.

Hygiene of the voice:

Infections of the throat may be minimised by avoiding crowded places particularly poor in ventilation as for *e.g.* a cinema house during a matinee show. Smoking, excess of alcohol, too cold or hot drinks are detrimental to the voice. *Yoga-asana*-s, especially the *sarvanga-asana* posture is said to have a beneficial effect on the voice by improving the circulation in the larynx.

Many drugs and household remedies are in vogue and are believed to improve the quality of the voice. Except for keeping the throat dry where there is a tendency for oversecretion of the glands or for stimulating secretion for lubrication of the throat in those prone to excessive dryness of the throat, these drugs do not alter the quality of the voice, since, most of them depend for their effect on local action and any local action on the vocal cords is precluded, since they cannot reach them unless directly applied over them, which is very difficult since they are almost inaccessible.

Hot drinks such as coffee or tea act by a general stimulation of the body and enhancing alertness and reducing fatigue. Benzedrine and its derivatives have a similar effect. On the other hand, an over excitable person may well need a tranquiliser.

Improvement of the voice by training implies a knowledge of the anatomy of the vocal apparatus and its working. Singing requires a very delicate co-ordination between the vibratory apparatus of the larynx and the muscles controlling the resonating cavities. In the case of the expert instrumentalist, it is the speed of execution of the delicately adjusted movements of the hands and fingers that contribute to his dexterity while manipulating the strings to produce the desired notes. The muscles of the hands and fingers respond to the impulses sent out from the storehouse of auditory impressions in the brain gathered in the course of training. The degree of dexterity of the instrumentalist is directly proportional to the amount of practice the muscles have been put. This holds good in vocal music as well. Given a normally functioning vocal apparatus, the success of a singer depends on how well the muscles of the vocal apparatus respond to what notes the artist desires to produce whether in singing a note of constant pitch or in producing a succession of alteration of pitches as in rendering *alap* in high speed. The traditional graded exercises have probably been devised by our ancients with this end in view, for progressive improvement and skill in the use of muscles of the vocal organs. While a teacher should endeavour to use in the time-honoured methods in training pupils, a certain amount of caution must be exercised, realising the limitations imposed by the differences in the anatomy of the vocal organs in the young immature pupil and the adult, especially while attempting to increase the compass or range of the voice of the pupil. The possibility of singers' nodes developing in the vocal cords should always be at the back of the mind. This nodule is the result of the two vocal cords striking each other with great intensity when increase in volume is attempted during the production of very high pitched notes, causing a break in the continuity of the mucus membrane, bleeding, and healing by formation of fibrous tissue, the same point being prone to damage by repetition of 'insults' to the vocal cords.

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